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A STUDY OF THE CESTODE PARASITES OF THE BLACK BASS IN OHIO, WITH SPECIAL REFERENCE TO THEIR LIFE HISTORY AND DISTRIBUTION.

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INTRODUCTION

These studies were first undertaken by the writer in the early summer of 1921 at the Lake Laboratory of Ohio State University at Put-in-Bay, Lake Erie, at the suggestion of Dr. R. C. Osburn, who had become interested in the larval stages of a proteocephalid found in the intestinal tract of young small-mouth bass (*Micropterus dolomieu*) just off their nest. At this time they measured 13–15 mm. The finding of large numbers of plerocercoids at such an early stage gave a clue as to the possible life history. Two possibilities were offered: either a direct infection or an infection through an intermediate host.

The earlier studies on the food of the young bass by E. L. Wickliff ('20) and Turner and Kraatz ('20) had shown that definite food cycles were present. Examinations were made of hundreds of these young bass, studying especially the stomach contents to discover the origin of the plerocercoid.

The studies also included an examination of the life history of two other cestode species found in the bass, studies of distribution of cestode species and on the degree of parasitism of bass in the state. In addition to the material collected during the summers of 1921 and 1922 many adult and young large- and small-mouth bass were examined from various sections of the state.

The methods were those ordinarily used for cestodes. La Rue ('14) gives the methods used in his study of Proteocephalidae and in the main these were followed.

LIFE HISTORY OF PROTEOCEPHALUS PEARSEI LA RUE 1919

(Figs. 1, 2, 4, 14, 20.)

The larval proteocephalids found in the young small-mouth bass proved to be *P. pearsei*. The hosts given by La Rue for this species are *Perca flavescens* and *Ambolplites rupestris*. A very close series was obtained from the plerocercus to the adult.

In 1921 the bass left their nests the second week in June. Early in the season eighty per cent of the fish were infested. The average number of larvae per fish ranged from 4 to 12 on different days. In 1922 the infestation was much heavier. Nearly all were infested and early in the season 15 to 30 larvae were found in a fish. Later the infestation was much lighter.

Hosts.—These cestodes were found in small-mouth bass (*Micropterus dolomieu*), large-mouth bass (*M. salmoides*), rock bass (*Ambloplites rupestris*), blue gill (*Lepomis pallidus*), perch (*Perca flavescens*), and white bass (*Roccus chrysops*). In nearly every case they were found in young fish.

But little is known concerning the life history of the Proteocephalids. La Rue ('14) reviews the data and says concerning the intermediate hosts of the Protocephalids, "From the data presented by various workers it seems probable that the life history of the Proteocephalids is as follows: The eggs and some of the ripe proglottids bearing eggs are voided by the host into the water where they are eaten by some invertebrate, perhaps a worm, an insect larva, or a crustacean or possibly the eater is a vertebrate, fish, snake or amphibian of the same species as the host or different. If the invertebrate or vertebrate furnishes a suitable habitat for the development of the parasite it develops a plerocercoid about which the host produces a cyst, etc."

The work of Janicki and Rosen ('17) and Rosen ('18) offers some very important contributions to the life history of cestodes. Their papers were not seen until these studies were completed. Rosen was successful in solving the life histories of three cestode species by experimental methods. After studies with many groups of invertebrates under carefully controlled conditions, Rosen obtained positive results. He infected *Cyclops strenuus* and *Diaptomus* with the eggs of *Dibothriocephalus latus L.* Rosen says, "Three months after infection the larvae are still

living and fixed to the external wall of the intestine." The next stage of these studies was the infection of the fish which are second intermediate hosts of *D. latus*. Young trout were fed cyclops and Diaptomus which had been infected six weeks previously. The activated procercoids penetrate the muscular wall of the stomach and migrate to the liver or muscular tissues where the plerocercoid develops.

P. pearsei offered a favorable form for a life history study. The infection is obtained early while the food is made up of from 80% to 90% copepods. There was no other parasitism in the young bass at the first appearance of the infection. The copepods comprising the early food of the young bass consisted of: *Epischura lacustris*, *Diaptomus sicilis*, *Cyclops leuckarti*, *Cyclops serrulatus*, *Cyclops albidus* and *Cyclops prasinus*. *Cladocerans* and *ostracods* furnish a small part of the early fish food. The bass cease to eat copepods shortly after they reach 40 mm. After this time no plerocercoid stages were found.

The studies in 1921 yielded no definite results as to determination of an intermediate host. Early in the summer of 1922 a plerocercus was found in the body cavity of a species of *Cyclops*. The plerocercus was in the posterior part of the body cavity and its slow movements could be seen through the body wall. Further search resulted in finding many of these infested copepods. These were secured both in tow and by a careful examination of the stomach contents of the young bass. July 4, 1922, 12 of these infested copepods were found in tow at Put-in-Bay. In the stomach contents of a 20 mm. bass taken the same day 2 plerocercoids were seen emerging from a partially digested cyclops. Others were found shortly after emergence. Later *Epishura lacustris* was also found carrying this plerocercoid in the body cavity. Three individuals of this species were found that were infected.

The plerocercoid escapes as the copepod is digested and then passes to the intestine, where growth is rapid. See Figs. 1, 4, 14, for the early stages of the plerocercoid. Fig. 14 was drawn from a copepod taken in tow and was the earliest stage seen. Fig. 4 is a drawing of a somewhat later stage taken from cyclops found in stomach contents.

P. pearsei matures quickly, as shown by the early appearance of adult individuals, June 27, 1921, in an 18 mm. bass and in 1922 is indicated by the following records: On June 23, in a

17 mm. small-mouth bass there was found an individual with 10 proglottids. This cestode measured 4.9 mm. The scolex and one of the posterior segments are shown in Fig. 20. June 26, an 8 mm. individual was found with the posterior proglottids mature. This was found in a 17 mm. small-mouth bass. There were 25 larval *P. pearsei* in the intestine of this bass. July 2 in a 26 mm. small-mouth an individual 3.6 mm. long was found, with a neck 1.3 mm. long and 15 proglottids, the last two showing uterine pouches partially filled with eggs.

This cestode seems to be of but little economic importance, as most of them are lost the first season. There is but little correlation between degree of infestation and size of the fish.

Other Species.

Proteocephalus fluviatilis, new species.

(Figs. 8, 11, 13, 16, 18, 21, 22.)

The collections of this species were made from *Micropterus dolomieu* taken from southern Ohio streams. Individuals of this species were found in half of the bass examined. In most cases the infestation was heavy. This was the only cestode species found in this bass.

Diagnosis: Characters of the genus, worms of medium length, up to 180 mm., segmentation not very evident except in ripe proglottids, little wrinkling or folding. Head small and not set off from neck; suckers set well forward, close together; breadth of head, average 1.79 mm., 2.00 mm. maximum; length of head, average .089, 1.00 maximum. Diameter of suckers, average .079 mm. Fifth sucker muscular, functional, average .040 mm., in diameter .032–.045 and about .030 mm. deep. Neck 7, 5, 9, 10, 12, 16 mm. long by .5–.75 broad. First proglottid broader than long; .040 to .060 mm. long by .56 to .98 wide. Mature proglottid broader than long; 1.50 x .22–1.32 x .37–1.12 x .42–.90 x .50 mm. Ripe proglottids broader than long to quadrate, .90 x .55–.93 x .62–.63 x .64 mm. Genital sinus irregularly alternating in anterior one-third to one-half proglottid. Testes—two layers filling the space anterior to the ovary and between the vitellaria. Number of testes 73–98; average 84. Maximum diameter .084 x .068 mm., average .062 mm. x .046 mm. Vas deferens forming a compact coil extending on a line with the cirrus to the center of the proglottid. Cirrus pouch .160–.172–.212 long by .052–.060–.068 broad, average .185 x .055. Ratio of length of cirrus pouch to breadth of proglottid 2:7 to 2:9. Ductus ejaculatorius, 2–3 coils in cirrus pouch. Length of cirrus when protruded .058 to .098 by .03 mm. wide. Vagina anterior and dorsal cirrus pouch in most cases, extending straight

almost to the mid-line. Sphincter vaginæ weak. Receptaculum seminis anterior to the ovary. Vitellaria compact, follicules extending to anterior part of ovary, thinner in area of cirrus and vagina, but usually not absent. Ovary bilobed, connected by an arched mid-piece, thin and elongate in early proglottids, lobes thick and made up of separate parts in mature proglottids. Uterus with 3, 5, or 7 lateral outpocketings on either side.

Habitat: Intestine of *Micropterus dolomieu.*

The studies are based on about 100 stained and mounted specimens. Serial sections were useful for a part of the descriptions.

A large number of the worms were immature. The maximum length for the worms is 14, 16, and 18 cm. The segmentation is not marked, however, it is quite evident in ripe proglottids swollen with eggs. The worms have few folds or wrinkles and a weak muscular development. This is quite evident in the larval forms. The maximum breadth is 1.35–1.60 and is the greatest in the region of the mature proglottids.

The head (Fig. 16) is short and narrow. It is not set off from the neck. The suckers are well forward and are close together. The head measures .160–.20 mm. broad at the posterior margin of the suckers. The four suckers are placed very close together with sufficient room for the small fifth sucker at the apex. The suckers are nearly circular, muscular, cupped, and are from .064 to .098 mm. in diameter. The fifth sucker appears to be functional. It has a shallow cup and possesses musculature quite similar to the large suckers. It measures from .032–.045 in diameter by .026 to .034 mm. deep.

The length of the neck, as determined by measurement to the first segmentation visible in the stained specimen is 7–16 mm The neck is narrow, .2–.50 mm. wide. It is difficult to tell just where the neck ends, as the primordia of the reproductive organs appear early and there is a gradual increase in the development toward the posterior segments. The development of the reproductive organs is slower than in the other forms studied by the writer.

The early mature proglottids are much broader than long. In specimen 42: 8–1–21, 106 mm. long, in the 160th proglottid the breadth is 1.07 mm. and length .234 mm. The lobes of the ovary are separate, thin and elongate, each lobe 0.28 mm. broad by .040 mm. long. The testes are well developed and number 86. The vagina and cirrus sac, cirrus and ducts are

well developed. The vagina is widened at the anterior end. Fig. 21 shows a proglottid at a later stage than here described. The measurements of the 240th proglottid in this specimen (42) are 88 mm. by .45 mm. This proglottid is more nearly mature. The ovarian lobes are much thicker, closer together, compact, but still the separate divisions of the lobes can be distinguished. There are 311 proglottids in the specimen mentioned. Near the posterior end the reproductive organs are pushed aside by the uterine pouches. These fill almost completely the space between the follicles.

Fig. 22 is a drawing of a mature segment showing the early formation of the uterine pouches and Fig. 18 shows the conditions of a ripe proglottid filled with eggs. The ripe proglottids are more quadrate, measuring 84 x 70, 95 x 70, 90 x 80 mm.

The posterior proglottid is triangular in outline, the two lobes of the ovary crowded near the point of the triangle.

The genital pore is marginal and situated from the anterior third to near the middle of the proglottid, opening on a slight papilla in mature proglottids. The cirrus is elongate, ovoid, broadest at the inner end. The cirrus is straight, measuring .060–.100 in length when extended. The ductus ejaculatorius is thrown into from 1 to 3 coils in the cirrus sac. The vas deferens extends as a dense mass of coils to the middle of the proglottid. In ripe proglottids the coils of the vas deferens and vagina are pushed together in a small area by the uterine pouches.

The testes lie in two layers and number from 74–98. They measure from .056 x .040 to .084 x .068 mm.

The vagina usually opens slightly dorsal to the cirrus pouch and is anterior to it. It does not cross the cirrus pouch. In a few cases the vagina is ventral to the cirrus pouch. This is in specimens that were flattened while killing and fixing and it is probable that pressure altered the relations. The sphincter vaginae is very weak. It is located near the vaginal opening. The vagina curves gently to the mid-line and passes to near the ovary where it is thrown into a number of coils, both anterior and posterior to the arch connecting the ovarian lobes. The seminal receptacle is present as a pouch-like enlargement of the vagina anterior to the ovarian lobes. It was found only in earlier mature segments. The vitelline ducts and the circular shell gland could be seen in certain proglottids.

The vitellaria are follicular, forming a close mass at the lateral portions of the segment. The vitellaria are only partially interrupted by the cirrus sac and vagina. The vitellaria are situated .110 mm. from the margin in mature segments.

The uterus has few lateral outpocketings of large size. Most of these pockets are nearly straight and press against the vitellaria. They number 3, 5, and 7. The embryo measures .012–.014 mm. The three membranes were not measured.

Larval Stages.

(Fig. 8.)

The life history of this species has not yet been determined. The studies were made too late in the autumn of 1922 to determine an intermediate host. Young bass contained large numbers of these larval cestodes. It has not been possible to study these bass in the Ohio River drainage early in the year. The first young bass examined measured from 40 to 55 mm. These were from Anderson's Fork, Clinton County, and were obtained August 1, 1922. They contained many larval cestodes in the intestine, resembling the forms in the adult bass from the same stream. August 30, 1922, five specimens of small bass were obtained from the Olentangy River, Franklin County. All these were heavily infested with the small larval cestodes. September 19, 1922, four young small-mouth bass measuring 57, 62, 71 and 77 mm. were studied. There were from 20–60 larval cestodes in each of these fish. These cestodes formed a tangled mass in the intestine and occupied a larger mass than the digested food. See Fig. 8 for drawings of the scolex of these larval cestodes. Their musculature was weak. Their movements were slow and they broke apart easily.

Proteocephalus osburni, new species.

(Figs. 3, 15, 17, 19.)

This description is based on a single immature individual secured from a 57 mm. small-mouth bass taken by Dr. R. C. Osburn at the Akron Hatchery, August 28, 1922. There are so many characteristic differences and the structures are so definite that this individual is described as a new species. It is hoped that more material can be secured and a more adequate description given.

Diagnosis: Characters of the genus, size small, specimen immature, measuring 19 mm.; scolex (Figs. 3, 15) .140 broad by .060 mm. long; suckers deeply cupped, set well forward on the head. They measure .050 mm. in diameter. The fifth sucker is at the apex of the scolex and is .028 in diameter by .024 mm. deep. The neck is very long, 14 mm. to first trace of segmentation. The neck is .50–.60 mm. broad. There are but seven proglottids in this individual. The first measures .22 mm. long by .80 mm. broad, showing an abrupt widening from the neck. The next proglottid, (Fig. 19), shows well formed testes in a single layer. This proglottid measures .50 mm. in length and 1.00 mm. in breadth. The fourth proglottid shows the first indication of development of uterine pouches and measures .80 mm. in length by 1.25 mm. in breadth, (See Fig. 17). The seventh or end proglottid measures 1.10 mm. in length by .92 mm. in breadth. It is rounded at the posterior end.

The genital sinus is lateral and situated two-fifths to one-half the length of the proglottid from the anterior end. There is a genital papilla which is much more marked than in the case of *P. fluviatilis.* The vagina opens anterior to the cirrus. There is no evidence of a sphincter vaginae. The vagina is larger in diameter than in *P. pearsei.* The diameter is not constant. Near the vaginal opening the diameter is .016 to .020 mm.; the central portion near the inner end of the cirrus sac measures .007–.010 mm. Just anterior to the ovarian lobes the vagina is thrown into a loose coiled mass. This occupies a larger space than the coils in *P. fluviatilis.* The measurement of the vagina here is .016–.024 mm. and posterior to the straight connection of the ovarian lobes there are more coils of the vagina. The vaginal walls thicken and the diameter here is from .024 to .040 mm. No trace of a seminal recepticle was found.

The cirrus sac is V-shaped, the broadest part being near the genital opening. The cirrus sac is much larger than in *P. fluviatilis* and *P. pearsei.* It measures .320 x .112 mm.; .280 x .100 mm.; .360 x .80 mm. and .320 x .072 mm. in four proglottids. Both the cirrus and ductus ejaculatorius are coiled inside the cirrus sac, the latter being thrown into two to four loose coils. The cirrus is about twice the diameter of the ductus ejaculatorius. The extended cirrus was not seen. The vas deferens forms a narrow coiled portion extending to the center of the segment. The coiled portion is thicker at the center of the segment. The coils are loose and less in number than the other forms referred to by the writer.

The testes are in a single layer, closely pressed together between the vitellaria. They number from 50–60. They are modified by being pressed together. The average measurement is .068 x .052 mm. They vary from round to long ovoid form. The vitellaria are fine, densely packed and more numerous just anterior to the ovary. The vagina and cirrus sac completely interrupt the vitellaria.

The ovarian lobes are large, thick, heavy and irregular in outline and fill the posterior part of the segment except for a small area between the lobes. The mid-piece connecting the lobes is not arched in fully

mature segments. The lobes measure .310 mm. in maximum length and .468 mm. in maximum breadth.

The uterine pouches are formed in the fourth segment. They are small, straight and overlap. The counts of uterine pouches are 11–9, 10–8, 9–5, to 10–7, the lower number of pouches being on the side of the genital ducts. These pouches reach to the vitellaria in many cases.

Proteocephalus ambloplitis (Leidy).

(Figs. 5, 6, 7, 9, 10, 12.)

This species was found in the adult bass of Lake Erie. Twenty-five of sixty adult small-mouth bass taken within a few miles of Put-in-Bay were found infested. They had from 1–8 cestodes, the scolex usually fastened to the inside wall of the pyloric caeca and the strobila reaching into the intestine.

The larvae of this species are very abundant in many young fish. The larval cysts were found in very young fish attached to the mesenteries and in the visceral organs. They were often found in long thin-walled cysts confined to the peripheral portion of the liver. The worms show a slight activity within the cyst. The amount of infestation was not large in the young small-mouth bass. There was a much larger degree of infestation in the young large-mouth bass. Occasionally the liver and spleen were completely riddled by these parasites. In a few cases these plerocercoids were found inside the phyloric caeca.

Almost the same degree of infestation is found in the adult bass. In this case the cestodes were larger, often coiled about in the liver, reaching a length of 4–6 cm. No sexually mature individuals of *P. ambloplitis* were found during the first year's growth of bass.

The external and histological features of these plerocercoids have been well described by Cooper ('15). Cooper's data give records for 9 adult *M. dolomieu.* The present studies cover the examination of a large number of young large- and small-mouth bass. Several very early stages were found. The smallest of these plerocercoids were found in the mesenteries. Some specimens measured .16–.25 mm. in length, (see Figs. 5, 6). Some of these smaller forms were found imbedded in the muscular wall of the intestine of a large-mouth bass 26 mm. long. These young stages show the invaginated scolex in the process of formation. (Figs. 5, 6, 9, 10, 12). The four suckers seem to develop in the angles of a common area. The fifth sucker is the earliest to form, but remains vestigial.

Cooper ('15) failed to find an intermediate host for this form, but says concerning the life history, "Thus the evidence points to *P. ambloplitis* having at least two intermediate hosts, the first in some unknown species of arthropod, and the second either a different species of minnow, small perch or final host itself." My studies include the examination of younger bass than those of Cooper and offer additional evidence that this suggested life history is probably a correct one.

However, the plerocercus must reach the bass at a very early stage, soon after the bass come off the nest. The earliest forms found in the mesenteries are quite small and appear early in the life of the fish. These plerocerci must be carried by some of the copepods as the small-mouth bass scarcely ever eat amphipods. Also the liver and mesentery cysts are found in both large and small-mouth bass before they take amphipods. It must be an entomostracan and probably a copepod common in the diet of the bass at Put-in-Bay and the large-mouth bass along the harbors of the Ohio mainland. The young large-mouth bass show the heaviest infection. In these fish taken from West Harbor there were often 25–40 mesentery cysts and 6–10 liver cysts in a young fish measuring 25–37 mm. These young fish furnish the second intermediate host and development progresses rapidly. At this stage development is seen especially in the increase in size, muscular formation and in the further development of nervous and excretory systems.

In *Hyalella knickerbockeri* Bate, taken in tow at Put-in-Bay Harbor, encysted plerocerci were found. They were too large for *P. pearsei* plerocercoids, (see Fig. 7). In 12 *Hyalella* examined, 6 were infested with one or two of these plerocerci. These may be the plerocerci of *P. ambloplitis*. *Hyalella* is scarce at Put-in-Bay and not an important portion of the diet of the bass. At East and West Harbors several hundred of these amphipods were examined, but no plerocerci were found. If *Hyalella* is an invertebrate host for *P. ambloplitis*, there must also be another form, as these amphipods are too scarce to account for the degree of infestation and often young bass have the cysts before *Hyalella* is an article of diet.

Distribution of Cestodes.

La Rue ('14) gives a summary of hosts reported and localities for the *proteocephalidae* in amphibians, reptiles, and fish. *P. ambloplitis* is the only form reported for the bass. *P. ambloplitis* is known only from waters which drain into the St. Lawrence and Red River of the North, according to La Rue.

Prof. H. B. Ward (La Rue '14), examined the proper host species in the Illinois river, but the cestode was not found.

It was not found as adult in any of the 200 adult small-mouth bass examined from the Olentangy River, Little Miami River, Caesar's Creek, Paint Creek and other streams of the Ohio River drainage. In adult large and small-mouth bass examined from Newtown, London and Akron State Hatcheries, no adult *P. ambloplitis* were found. In a few cases larval cestodes of this species were found encysted in the livers. The probability is that these were in bass introduced from Lake Erie. This was known to be the case for those examined at one of the hatcheries. It seems likely that this cestode would be introduced in streams where adult bass from Lake Erie had been placed, but perhaps the proper invertebrate host is not present. The only record for finding the adult *P. ambloplitis* in the Ohio River drainage was at Lake Chautauqua, N. Y., where two adult bass had a heavy infestation. Many others showed only larval cysts in the viscera.

Proteocephalus fluviatilis.

This cestode was found only in *M. dolomieu* in southern Ohio streams. No other hosts were found for this species.

Proteocephalus pearsei.

This form was confined to the younger fish in Lake Erie and the Lake drainage. In a few cases this cestode was found in older fish. None were found in the Ohio River drainage.

Proteocephalus exiguus.

This form was not found in Ohio, but was found in *M. dolomieu* in material collected by Needham and Sibly, at Lake George, N. Y.

Pseudophyllidean Cestodes.

Cooper ('18) revised the family describing the forms belonging to this group and including several new species from North American fish. Two species of larval cestodes belonging to this group were found in small-mouth bass. They were found only in a few cases and perhaps represent chance infestation.

Triaenophorus nodulosus (Pallas).

Two specimens of this species were discovered both encysted in the liver. They were coiled in an oval cyst near the periphery of the organ. One was found in a young small-mouth bass and the other in an adult of 27 cm.

Bothriocephalus claviceps (Goeze 1784).

Adult specimens of this cestode were found in the upper intestine of a rock bass (*Ambloplitis rupestris*). Larval forms were found in four small-mouth bass; two from 10 cm. individuals secured near Put-in-Bay, one from an 11 cm. small-mouth from Maumee Bay, and one from an adult small-mouth taken from Anderson's Creek, Clinton County, Ohio.

SUMMARY.

1. The studies include examination of a large number of adult and young specimens of large and small-mouth bass from many sections of Ohio and from Lake Erie. In the small-mouth bass seven species of cestodes were found. Two of these were new species and six had not been previously reported for the bass. In large-mouth bass two species of cestodes were found.

2. By intensive study of young bass from the time they leave their nests it is shown that certain cestodes are obtained early, while the food is chiefly copepods.

3. The factors involved in a life history study are date of infection, age of fish, and food of fish at the time.

4. The life history of one proteocephalid (*P. pearsei*) was demonstrated. The intermediate host may be either of two species of copepods, *Epishura lacustrius* or a small species of *Cyclops*.

5. The studies on the early larval stages of *P. fluviatilis* indicatea life history similar to *P. pearsei.*

6. Evidence points to two intermediate hosts for *P. ambloplitis;* one an *Entomostracan* and the other a minnow or young fish of the same species as the host of the adult *P. ambloplitis.*

7. There are different cestode parasites in the bass in Lake Erie and its drainage system from those in the Ohio River drainage.

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EXPLANATION OF FIGURES.

PLATE I.

All drawings have been with the aid of the camera lucida and the scale given with each.

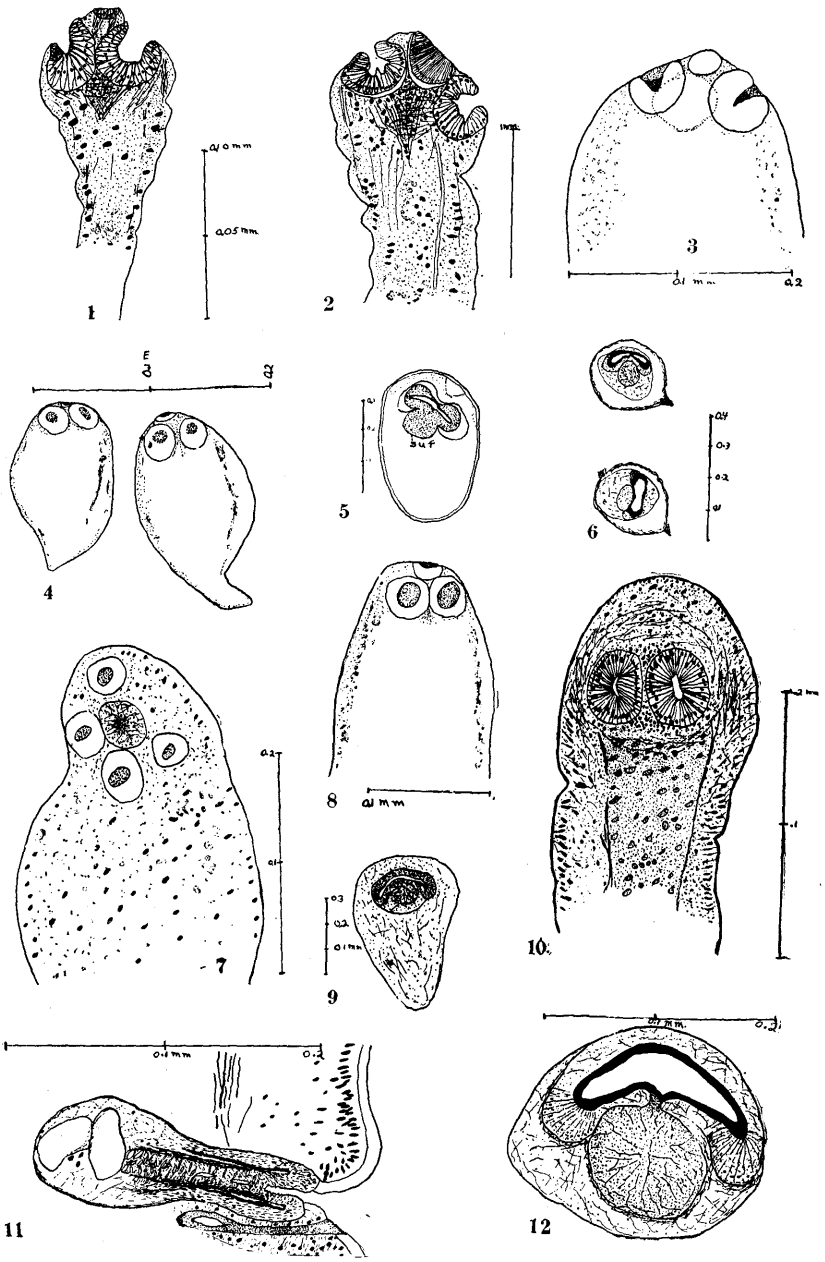
Abbreviations used:

Ci—Cirrus.
Mf.—Muscle fibers.
Ov—Ovary.
Sg.—Shell gland.
Sr.—Receptaculum seminis.
Suf.—Fifth Sucker.
T—Testes.
Utl.—Lateral uterine pouches.
Va.—Vagina.
Vas—Sphincter vaginae.
Vd—Vas deferens.
Vi—Vitellaria.

Fig. 1. Proteoce.halus pearsei, head of larva, longitudinal section showing structure of suckers, etc.
Fig. 2. Proteocephalus pearsei, head of adult, longitudinal section.
Fig. 3. Proteocephalus osburni, head, one of four suckers shown by dotted line ventral, not indicated, adult, type specimen.
Fig. 4. Proteocephalus pearsei, larvae, the smaller taken from cyclops, the other from the stomach contents of 15 mm. small-mouth bass, 6-20-22.
Fig. 5. Proteocephalus ambloplitis, plerocercoid from the liver cyst showing formation of suckers.
Fig. 6. Proteocephalus ambloplitis, early plerocercoids from mesentery cysts.
Fig. 7. Plerocercoid taken from body cavity of Hyalella knickerbockeri.
Fig. 8. Proteocephalus fluviatilis, head toto, larval.
Fig. 9. Proteocephalus ambloplitis, plerocoid from mesentery cyst.
Fig. 10. Proteocephalus ambloplitis, longitudinal section of plerocercoid from intestine of young large-mouth bass to show details of suckers etc., section not through center of plerocercus.
Fig. 11. Proteocephalus fluviatilis, cirrus, cirrus pouch, and portion of vagina. Note.—The vagina is dorsal to the cirrus sac. This drawing is inverted.
Fig. 12. Proteocephalus ambloplitis, portion to show details of developing suckers and vestigial fifth sucker of plerocercus.

PLATE II.

Fig. 13. Proteocephalus fluviatilis. Section showing cirrus, portions of vagina and ovarian lobes.
Fig. 14. Cyclops prasinus with plerocercus in body cavity, appendages removed from cyclops.
Fig. 15. Proteocephalus osburni, head, toto.
Fig. 16. Proteocephalus fluviatilis; head, adult toto.
Fig. 17. Proteocephalus osburni, ripe prolgottid, toto.
Fig. 18. Proteocephalus fluviatilis, ripe proglottid toto showing filled uterine pouches, type specimen.
Fig. 19. Proteocephalus osburni, early mature proglottid toto.
Fig. 20. Proteocephalus pearsei, early mature individual from 17mm. small-mouth bass collected 6-22-22.
Fig. 21. Proteocephalus fluviatilis, toto early mature proglottid showing testes and relations of cirrus and vagina.
Fig. 22. Proteocephalus fluviatilis late mature proglottid showing formation of lateral uterine pouches and more typical vagina than in preceding stage.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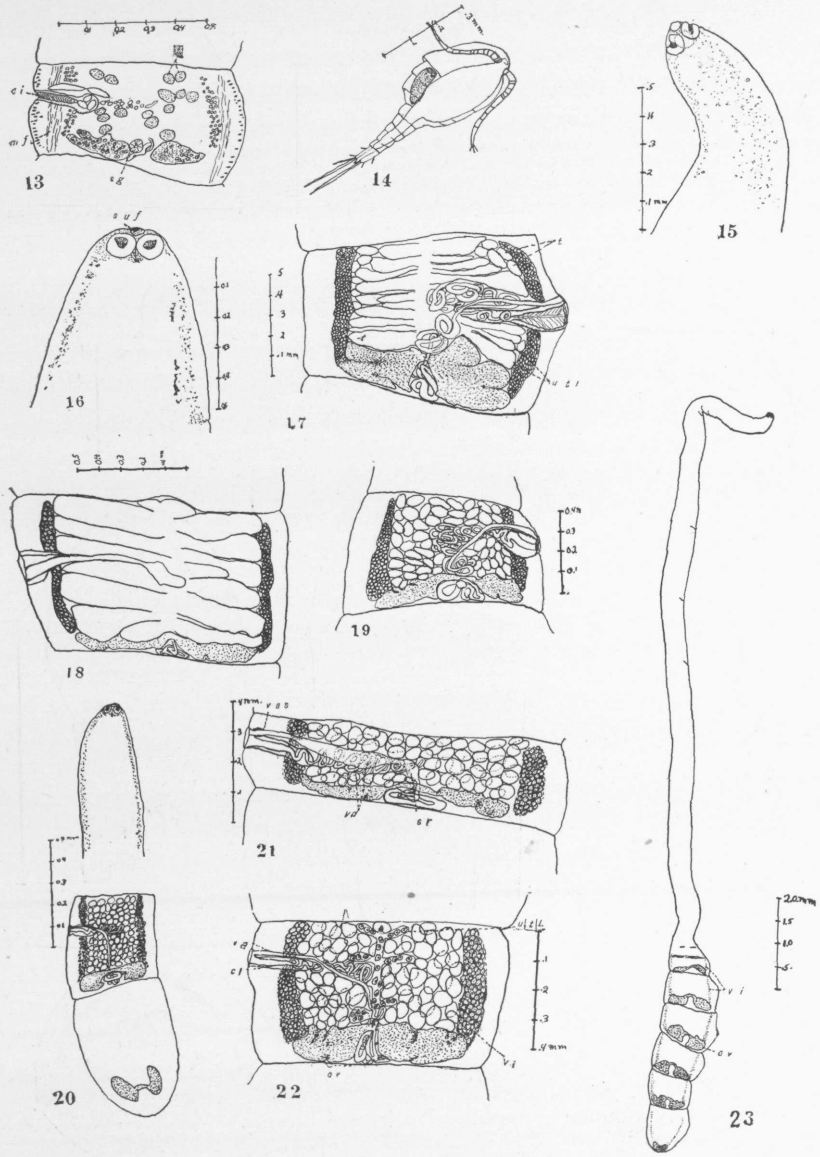
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